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GLOBEC NEP: Satellite-observed Ocean Climate Variability

Andrew C. Thomas
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Principal Investigator: Thomas, Andrew C.
Award ID: 0000899
Organization: University of Maine
Title:
GLOBEC NEP: Satellite-observed Ocean Climate Variability

Project Participants

Senior Personnel

Name: Thomas, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Son, Seung Hyun
Worked for more than 160 Hours: No
Contribution to Project:
SuengHyun wrote IDL code in support of some of the satellite data analyses.

Name: Henson, Stephanie
Worked for more than 160 Hours: No
Contribution to Project:
Stephanie was supported briefly by this grant as she began her post doc research at U.Maine investigating time/space variability of chlorophyll
in the California Current system.

Graduate Student

Name: Legaard, Kasey
Worked for more than 160 Hours: Yes
Contribution to Project:
Kasey began his MS research in September 2001, focussing on developing the use of geostatistical tools for ocean color data analysis. His study area is the California Current. He has used semi-variogram analysis, and the pre-filtering that must preceed this analysis, to separate the temporal variability evident in time series of SeaWiFS images into 1) interannual, 2) seasonal, 3) subseasonal, and 4) unresolved components.
With each of these, he is able to develop maps, which quantify spatial patterns in the relative components of each. Kasey is currently writing and expects to graduate within the next few months.

Name: Bosch, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
Jennifer was an MS student, under the supervision of Andrew Thomas.
Her research topic was temporal variability in chlorophyll patterns around Heceta Bank and along the Oregon coast in the California Current

Undergraduate Student

Technician, Programmer

Name: Brickley, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:

Peter is an oceanographer/data analyst working in the Satellite Oceanography Data Lab at U.Maine under the direction of Andrew Thomas. Partial time over the year has been spent working on GLOBEC data and partial support for his position has been derived from this grant. Peter's primary responsibility has been data sets associated with the Gulf of Alaska and each of the 4 global eastern boundary currents.

Name: Weatherbee, Ryan

Worked for more than 160 Hours: Yes

Contribution to Project:

Ryan is a Research Associate working under the supervision of Andrew Thomas. Ryan's promary responsibility in this project has been processing and analysis of 1km SeaWiFS multispectral data over the GLOBEC study region.

Other Participant

Research Experience for Undergraduates

Organizational Partners

Oregon State University

Separate NSF annual report will be submitted by OSU

Ocean Imaging

A separate annual report will be submitted by Ocean Imaging

Other Collaborators or Contacts

Jose Luis Blanco, Instituto de Fomento Pesquero, Valparaiso, Chile
Mary-Elena Carr, NASA-JPL, CA
Frank Schwing, NOAA PFEL
William Crawford, Institute of Ocean Sciences, British Columbia
Pat Wheeler, Oregon State University
Jane Huyer, Oregon State University
Mike Dagg, LUMCON, LA
Tawnya Peterson, UC Santa Cruz
Scott Nixon, U. Rhode Island
David Mackas, Institute of Ocean Sciences, British Columbia

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Kasey Legaard continues his M.S. work at U.Maine under the direction of Andrew Thomas. His research topic is focused on quantifying the time and space scales of chlorophyll variability from SeaWiFS in upwelling regions. He has implemented a suite of geo-statistical tools which allow estimation of variance and decorrelation scales at specific locations for comparison to bathymetry, wind forcing and offshore eddy activity.

Outreach Activities:

My web site displays my data sets as well as descriptions of
the project (www.seasurface.uMAINE.EDU). All data sets have also
been transfered to the GLOBEC data server at Oregon State University COAS where they are made available.

Journal Publications

Thomas, A.C., J.L. Blanco, M.E. Carr, P.T. Strub, and J. Osses, "Satellite-measured chlorophyll and temperature variability off northern Chile during the 1996-1998 El Nino and La Nina.", J. Geophys. Res., p. 899, vol. 106, (2001). Published

Blanco, J. L., A. C. Thomas, M. E. Carr, and P. T. Strub, "Seasonal climatology of
hydrographic conditions in the upwelling region off northern Chile

", J. Geophys. Res
, p. 11451, vol. 106, (2001). Published

Blanco, J. L., M. E. Carr, A. C. Thomas, and P. T. Strub, "Hydrographic conditions off northern Chile during the 1996-1998 El Nino and La Nina", J. Geophys. Res, p. 3-1, vol. 107, (2002). Published

Thomas, A.C., and P.T. Strub, "Cross-shelf phytoplankton pigment variability in the California Current", Cont. Shelf Res, p. 1157, vol. 21, (2001). Published

Nixon S. and A.C. Thomas, "On the size of the Peruvian upwelling ecosystem", Deep-Sea Res, p. 2521, vol. 48, (2001). Published

Thomas A.C., P. Ted Strub, M.E. Carr and R. Weatherbee, "Comparisons of chlorophyll variability between the four major global eastern boundary currents", Int. J. Rem. Sens, p. , vol. , ( ). Accepted

Townsend D.W. and A.C. Thomas, "Winter-spring transition of phytoplankton chlorophyll and inorganic nutrients on Georges Bank", Deep-Sea Res, p. 199, vol. 48, (2001). Published

Thomas A.C., M.E. Carr and P.T. Strub, "Chlorophyll variability in eastern boundary currents", Geophys. Res. Lett., p. 3421, vol. 28, (2001). Published

Andrew Thomas, P. Ted Strub, and Peter Brickley, "Anomalous satellite-measured chlorophyll concentrations in the northern California Current in 2001-2002
", Geophysical Research Letters, p. , vol. , (2003). Accepted

Andrew Thomas and Peter Brickley, "Satellite-measured Seasonal and Inter-annual Chlorophyll Variability in the Northeast Pacific and Coastal Gulf of Alaska
", Deep Sea Research 2, p. , vol. , ( ). Submitted

Mary Elena Carr, P. Ted Strub, Andrew Thomas and Jose Luis Blanco, "Evolution of 1996-1999 La Nina and El Nino conditions off the western coast of South America: a remote sensing perspective", Journal of Geophysical Research, p. 29-1, vol. 107, (2002). Published

Legaard, K. and A.C. Thomas, "Spatial patterns of intraseasonal variability of chlorophyll and sea surface temperature in the California Current.", J. Geophys. Res., p. , vol. , ( ). Submitted

Thomas, A.C. and P. Brickley, "Satellite measurements of chlorophyll distribution during spring 2005 in the California Current.", Geophys. Res. Letters, p. 22, vol. 33, (2006). Published

Legaard, K. and A.C. Thomas., "Spatial patterns of seasonal and interannual variability in chlorophyll and surface temperature in the California Current", J. Geophys. Res., p. 06032, vol. 111, (2006). Published

Thomas, A.C. and R. Weatherbee, "Satellite-measured temporal variability of the Columbia River plume", Remote Sensing of Environment, p. 167, vol. 100, (2006). Published

Dagg, M.J., H. Liu and A.C. Thomas., "Effects of mesoscale phytoplankton variability on the copepods Neocalanus flemingeri and N. plumchrus in the coastal Gulf of Alaska.", Deep-Sea Res., p. 321, vol. 53, (2006). Published

Crawford, W.R., P.J. Brickley, T.D. Peterson, and A.C. Thomas,, "Impact of Haida Eddies on chlorophyll-a distribution in the eastern Gulf of Alaska", Deep-Sea Res., p. 975, vol. 52, (2005). Published

Books or Other One-time Publications

Mackas, D., P.T. Strub, A.C. Thomas, V. Montecino, "Eastern Ocean Boundaries Pan-Regional View", (2006). Book, Published
Editor(s): Robinson and Brink
Collection: The Sea
Bibliography: Harvard University Press

Montecino, V., P.T. Strub, J. Tarazona, F. Chavez, A.C. Thomas and T. Baumgartner., " Bio-physical interactions off western South America", (2006). Book, Published
Editor(s): Robinson and Brink
Collection: The Sea
Bibliography: Harvard University Press

Web/Internet Site

URL(s):
www.seasurface.umaine.edu
Description:
This is the general web site for the Satellite Oceanography Data Lab at U.Maine. One part of it describes our GLOBEC work and acknowledges NSF GLOBEC awards. It also has links to GLOBEC satellite data products.

Other Specific Products

Contributions

Contributions within Discipline:
We have calculated and summarized largescale cross-shelf pigment variability in the California Current, as viewed by CZCS, which until SeaWiFS was our best view of this region. These data now provide a baseline against which variability measured by SeaWiFS can be viewed.

Our 2001 GRL publication provides the first quantification of seasonal variability across the full latitudinal extent of each of the 4 global eastern boundary currents, allowing direct comparisons.

Our 2003 GRL publication quantifies the biological ramifications of a major hydrographic anomaly in the California Current in 2001-2002.

This was followed by our 2006 GRL publication quantifying the biological patterns of a major wind anomaly in the California Current in 2005.

Our Deep Sea Res (2004) manuscript provides the first synoptic view
of seasonal and interannual variability in chlorophyll concentrations
in the Gulf of Alaska

2 manuscripts by Legaard and Thomas describe space patterns of seasonal and non-seasonal chlorophyll and SST variability across the greater California Current system.

Ocean color data provide a new view of the time/space patterns of the Columbia River plume along the OR-WA shelf in Thomas & Weatherbee 2006.

Interactions between chlorophyll patterns and zooplankton distributions in the coastal Gulf of Alaska showed that mesoscale [chl] patterns had little impact on zooplankton body size (Dagg et al. 2006).

The role of mesoscale eddies in regulating chlorophyll pattrens in the Gulf of Alaska is outlined in Crawford et al. 2005

Please see actual publications for detailed results and discoveries.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

2 MSc thesis candidates partially supported
2 post docs partially supported.

Contributions to Resources for Research and Education:

3 data bases of fully processed SeaWiFS satellite images of chlorphyll
are maintained, updated continuously and made available to the community. These are of the Gulf of Alaska, the California Current region at 4km resolution and the Oregon/Washington coast at 1km resolution. Primary users are the Canadian and US GLOBEC investigators.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Any Product

Contributions: To Any Other Disciplines

Contributions: To Any Beyond Science and Engineering

Research Findings

Kasey Legaard's thesis research has produced maps that quantify the space pattern of variance associated with seasonal and interannual variability in the California Current. He continues to work towards his degree.

At a meeting in Valparaiso Chile, in January 2003 recent results of SeaWiFS analyses on the Southern Pacific were presented, showing the impact of El Nino, and comparing the timing to that off California.

Selected Figures are included below:

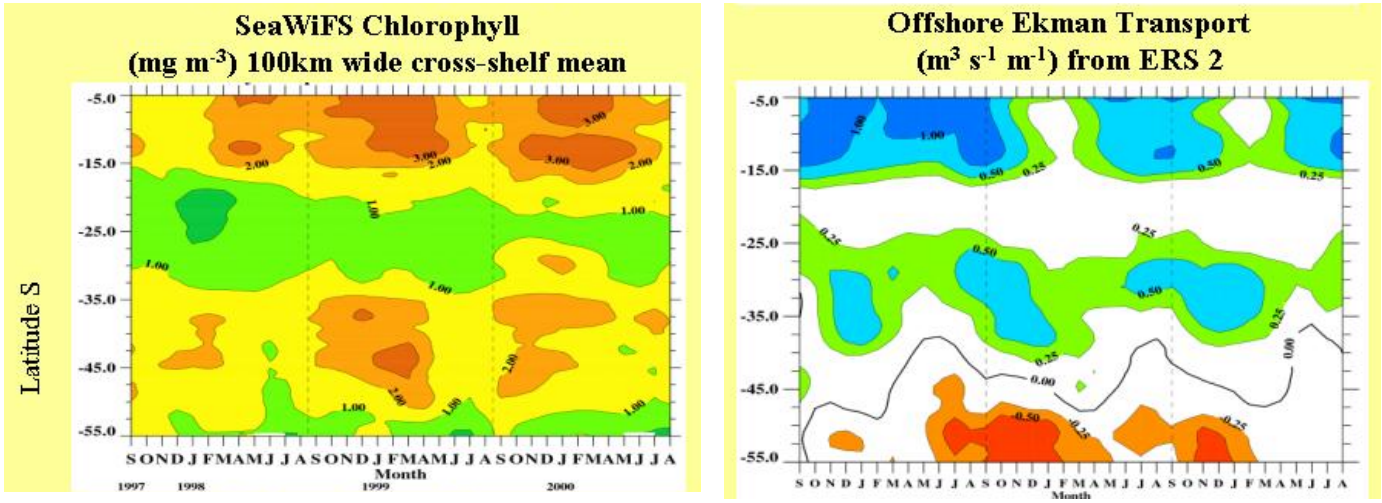
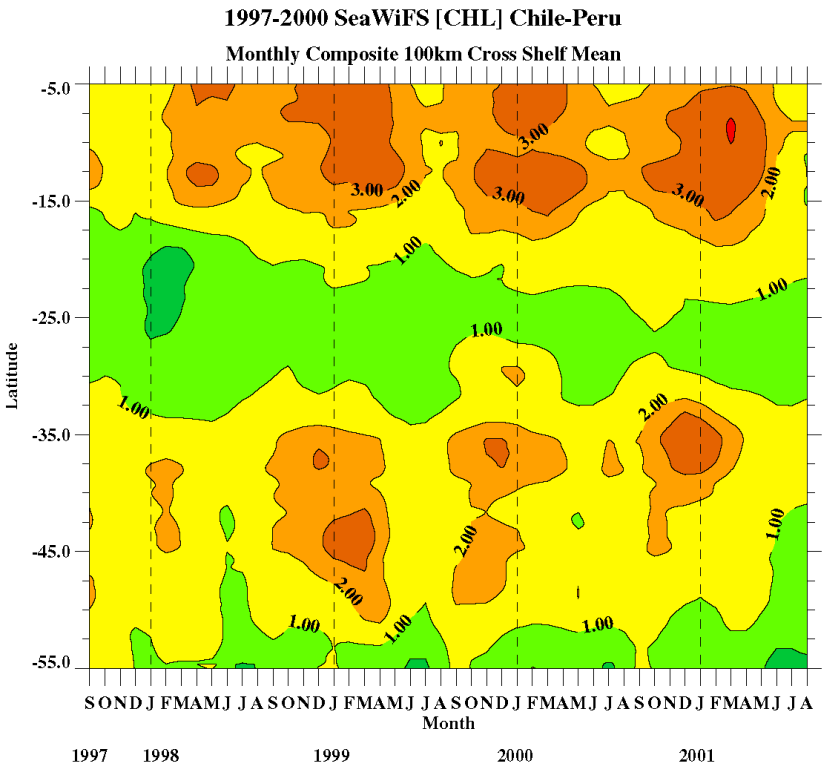


Figure 1. The above 2 figures compare wind forcing over 3 years to seasonal development of chlorophyll patterns within 100km of the coast along the South American coast.


1997-2000 SeaWiFS [CHL] Chile-Peru
Monthly Composite 100km Cross Shelf Mean
Latitude
-5.0
-15.0
-25.0
-35.0
-45.0
-55.0
3.00
2.00
1.00
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
Month
1997
1998
1999
2000
2001

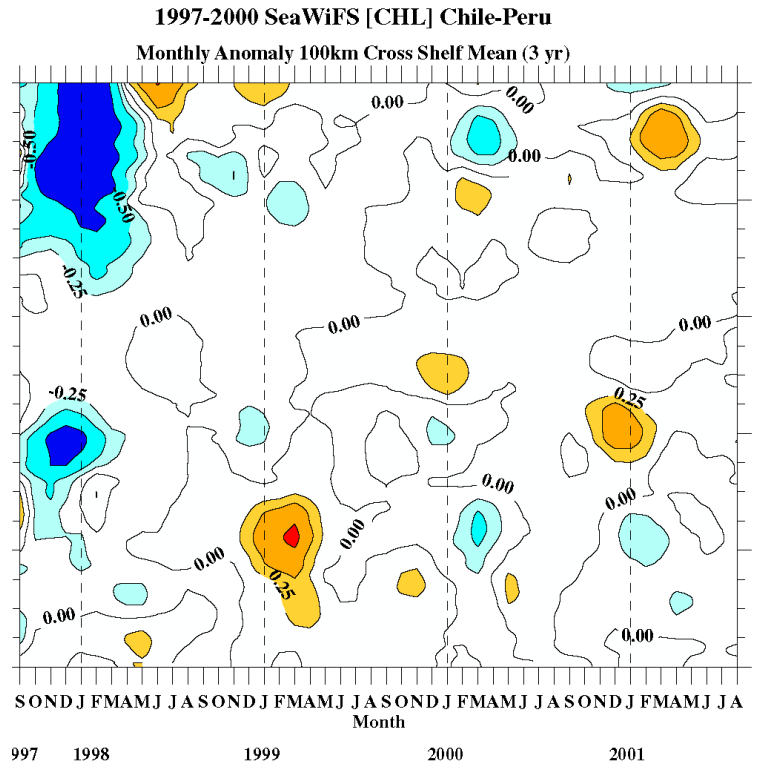

1997-2000 SeaWiFS [CHL] Chile-Peru
Monthly Anomaly 100km Cross Shelf Mean (3 yr)
0.50
0.25
0.00
-0.25
-0.50
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
Month
997
1998
1999
2000
2001

Figure 2. above. Latitudinal and seasonal contours of chlorophyll within 100km of the South American coast, showing anomalies from the 4 year mean. These highlight the strong negative anomalies during the El Nino and show its latitudinal impact.

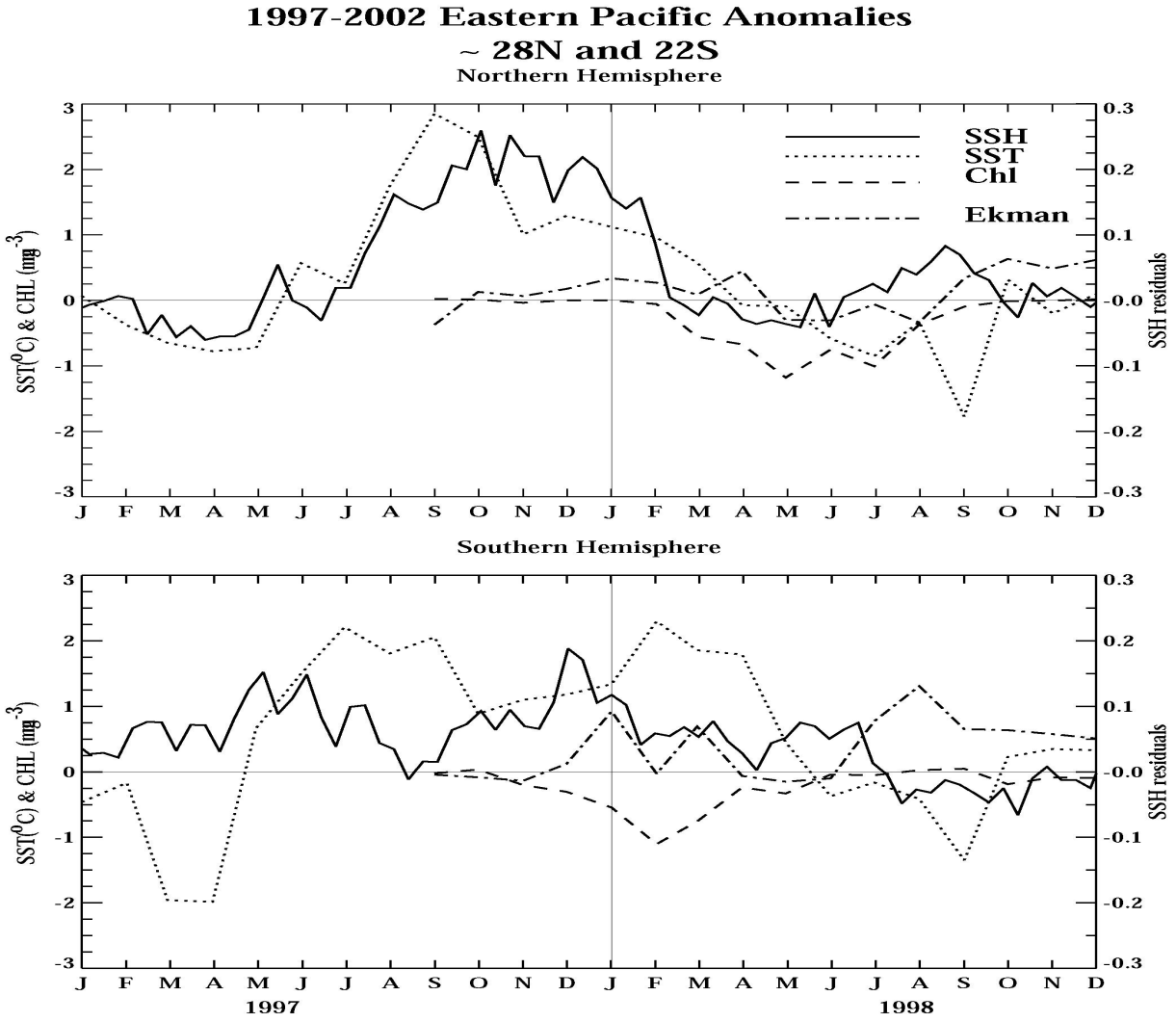


Figure 3. Comparisons of the timing of major El Nino signals in South America versus North America. Shown are the SSH signal from altimeter data, arriving earlier and in 2 clear signals off South America, and as a single signal off North America, SST anomalies from AVHRR, Ekman transport anomalies that do not explain either the SST or chlorophyll anomalies, and chlorophyll anomalies from SeaWiFS. These latter are strongly modulated by the seasonal cycles that are 180 degrees out of phase.

RESEARCH and EDUCATION ACTIVITIES

This grant (OCE-0000899) finished its fourth year, part of the multi-institutional U.S. GLOBEC program in the N.E. Pacific (NEP). OCE-0000899 resulted from a group proposal, other PI's are P. Ted Strub at Oregon State University (OSU) and Jan Svejkovsky at Ocean Imaging, Inc. (OI). NSF should receive separate (but with some duplication) annual reports for the companion grants to Strub and Svejkovsky. This report covers activities and results from the University of Maine portion of the group project (Thomas, PI).

Our proposed work consists of collection, archiving, distribution and analysis of satellite data in the Oregon / northern California region of the California Current System (CCS) and the shelf and slope region in the northern coastal Gulf of Alaska (CGOA) and over the larger-scale NE Pacific Basin. Our research activities include comparisons to other upwelling systems. The UM portion is specifically tasked with handling the ocean color (SeaWiFS) aspects of this effort. The original proposal lists three goals: 1) To quantify the seasonal and interannual variability in the small-scale and mesoscale circulation patterns around each of the NEP process sites (in the CCS and CGOA), while also examining the basin-scale forcing and circulation; 2) To analyze changes in timing and strength of the seasonal transitions; and 3) To quantify changes in upwelling strength and cross-margin transport and entrainment of nearshore water into the more offshore seasonal jet, using high-resolution satellite imagery.

Two overarching activities occur throughout the lifetime of project: 1) the acquisition, processing, archiving and delivery of ocean color satellite data fields and 2) the analysis of these data as the time series continually expands. In the 4th year, specific activities at University of Maine were:

1) Continue processing daily 4-km SeaWiFS chlorophyll fields in the CCS, adding to the database time series.
2) Continue processing daily 4-km SeaWiFS chlorophyll fields in the CGOA, adding to the database time series.
3) Continue collection of 1-km SeaWiFS chlorophyll fields in the Oregon Washington coastal region, over the survey locations, adding to the database time series;
4) Collect and process 1-km SeaWiFS chlorophyll fields for fixed intervals during the CGOA field season over the survey locations to support LTOP and Process cruises.
5) Continue processing daily 4-km SeaWiFS chlorophyll fields over other global eastern boundary current upwelling regions (Peru-Chile, Benguela, Canary Current regions), adding to the database time series.
6) Characterize and analyze seasonal and interannual variability of chlorophyll fields in the Gulf of Alaska.
7) Characterize seasonal and interannual variability of chlorophyll fields in the California Current.

Our current status on each of these activities is outlined below.

(1-2) Continuing from last year, the 4km resolution SeaWiFS time series of the CCS and CGOA are acquired electronically from the Goddard DAAC as they become available. These continue to be produced and archived. Our University of Maine web site allows users to browse the images as jpegs (www.seasurface.umaine.edu, NEP GLOBEC link) and digital data (as HDF files) are made available to the community by request. All digital data continue to be operationally copied to Oregon State University where HDF files are made available to the community via the OSU GLOBEC web site.

(3) SeaWiFS 1km fields are processed at OSU. At present, the 1km time series covers the period September 1997 (beginning of SeaWiFS mission) – August 2002. These data are also made available to the community upon request.

(4) A real time 1km data stream for specific cruise times in the CGOA was not initiated.

(5 - 6) This task is ongoing. Our present fully-processed SeaWiFS data set covering all 4 major eastern boundary current regions extends from September 1997 – Sept 2003.

(7) A manuscript on Gulf of Alaska large-scale chlorophyll variability has been submitted to the Deep-Sea Research II Special Issue on SeaWiFS Results is under review. A second manuscript is submitted with Bill Crawford (IOS, BC) examining co-varying chlorophyll and TOPEX height fields associated with eddies in the Gulf of Alaska.

(8) Jennifer Bosch continues to work on a draft manuscript from her thesis.

(9) The Geophysical Research Letters manuscript entitled "Anomalous satellite-measured chlorophyll concentrations in the northern California Current in 2001-2002" was published (Geophys. Res. Lett. 30(15): 8022, doi:10.1029/2003GL017409

10) Kasey Legaard continues to work on an MS thesis under GLOBEC NSF funding at U.Maine addressing time and space variability of chlorophyll in upwelling regions at scales less than monthly and 200km. He has implemented geostatistical techniques to quantify this variability and is able to produce maps of, for example, temporal decorrelation scale, separating seasonal from interannual and intraseasonal variability.